

Monofocal
translational
Axis I. Ciliary

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lens system

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Summary of Invention Paragraph - BSTX (7):

[0006] One aspect of the invention is an accommodating intraocular lens for implantation in an eye having an optical axis. The lens comprises an anterior portion which in turn comprises an anterior viewing element comprised of an optic having refractive power and an anterior biasing element comprising first and second anterior translation members extending from the anterior viewing element. The lens further comprises a posterior portion which in turn comprises a posterior viewing element in spaced relationship to the anterior viewing element and a posterior biasing element comprising first and second posterior translation members extending from the posterior viewing element. The anterior portion and posterior portion meet at first and second apices of the intraocular lens such that a plane perpendicular to the optical axis and passing through the apices is closer to one of said viewing elements than to the other of said viewing elements. The anterior portion and the posterior portion are responsive to force thereon to cause the separation between the

viewing elements to change.

Summary of Invention Paragraph - BSTX (8):

[0007] Another aspect of the invention is an accommodating intraocular lens for implantation in an eye having an optical axis. The lens comprises an anterior portion, which in turn comprises an anterior viewing element comprised of an optic having refractive power, and an anterior biasing element comprising first and second anterior translation members extending from the anterior viewing element. The lens further comprises a posterior portion which in turn comprises a posterior viewing element in spaced relationship to the anterior viewing element, and a posterior biasing element comprising first and second posterior translation members extending from the posterior viewing element. The anterior portion and posterior portion meet at first and second apices of the intraocular lens. The anterior portion and the posterior portion are responsive to force thereon to cause the separation between the viewing elements to change. The first anterior translation member forms a first anterior biasing angle, as the lens is viewed from the side, with respect to a plane perpendicular to the optical axis and passing through the apices. The first posterior translation member forms a first posterior biasing angle, as the lens is viewed from the side, with respect to the plane. The first anterior biasing angle and the first posterior biasing angle are unequal.

Summary of Invention Paragraph - BSTX (10):

[0009] A further aspect of the invention is an accommodating intraocular lens comprising an anterior portion which in turn comprises an anterior viewing element which has a periphery and is comprised of an optic

having refractive power. The anterior portion further comprises an anterior biasing element comprising first and second anterior translation members extending from the anterior viewing element. The lens further comprises a posterior portion which in turn comprises a posterior viewing element having a periphery, the posterior viewing element being in spaced relationship to the anterior viewing element, and a posterior biasing element comprising first and second posterior translation members extending from the posterior viewing element. The first anterior translation member and the first posterior translation member meet at a first apex of the intraocular lens, and the second anterior translation member and the second posterior translation member meet at a second apex of the intraocular lens, such that force on the anterior portion and the posterior portion causes the separation between the viewing elements to change. Each of the translation members is attached to one of the viewing elements at at least one attachment location. All of the attachment locations are further away from the apices than the peripheries of the viewing elements are from the apices.

Summary of Invention Paragraph - BSTX (23):

[0022] A further aspect of the invention is an accommodating intraocular lens. The lens comprises an anterior portion which in turn comprises an anterior viewing element having a periphery and comprised of an optic having refractive power, and an anterior biasing element comprising at least one anterior translation member attached to a first attachment area on the periphery of the anterior viewing element. The first attachment area has a thickness in a direction substantially perpendicular to the periphery and a

width in a direction substantially parallel to the periphery. The ratio of the width to the thickness is equal to or greater than 3.

Detail Description Paragraph - DETX (9):

[0085] As best seen in FIG. 4, the lens system 100 has an anterior portion 102 which is anterior or forward of the line A-A (which represents a plane substantially orthogonal to the optical axis and intersecting first and second apices 112, 116) and a posterior portion 104 which is posterior or rearward of the line A-A. The anterior portion 102 comprises an anterior viewing element 106 and an anterior biasing element 108. The anterior biasing element 108 in turn comprises a first anterior translation member 110 which extends from the anterior viewing element 106 to the first apex 112 and a second anterior translation member 114 which extends from the anterior viewing element 106 to the second apex 116. In the illustrated embodiment the first anterior translation member 110 comprises a right arm 110a and a left arm 110b (see FIG. 3). In addition, the depicted second anterior translation member 114 comprises a right arm 114a and a left arm 114b. However, in other embodiments either or both of the first and second anterior translation members 110, 114 may comprise a single arm or member, or more than two arms or members.

Detail Description Paragraph - DETX (10):

[0086] As best seen in FIGS. 4, 5 and 7, the posterior portion 104 includes a posterior viewing element 118 and a posterior biasing element 120. The posterior biasing element 120 includes a first posterior translation member 122 extending from the posterior viewing element 118 to the first apex 112 and a second posterior translation member 124 extending from the posterior viewing

element 118 to the second apex 116. In the illustrated embodiment, the first posterior translation member comprises a right arm 122a and a left arm 122b. Likewise, the depicted second posterior translation member 124 comprises a right arm 124a and a left arm 124b. However, in other embodiments either or both of the first and second posterior translation members 122, 124 may comprise a single arm or member, or more than two arms or members.

Detail Description Paragraph - DETX (11):

[0087] In the embodiment shown in FIG. 4, the anterior biasing element 108 and the posterior biasing element are configured symmetrically with respect to the plane A-A as the lens system 100 is viewed from the side. As used herein to describe the biasing elements 108, 120, "symmetric" or "symmetrically" means that, as the lens system 100 is viewed from the side, the first anterior translation member 110 and the first posterior translation member 122 extend from the first apex 112 at substantially equal first anterior and posterior biasing angles $\theta_{1,2}$ with respect to the line A-A (which, again, represents the edge of a plane which is substantially orthogonal to the optical axis and intersects the first and second apices 112, 116) and/or that the second anterior translation member 114 and the second posterior translation member 124 extend from the second apex 116 at substantially equal second anterior and posterior biasing angles $\theta_{3,4}$ with respect to the line A-A. Alternative or asymmetric configurations of the biasing elements are possible, as will be discussed in further detail below. It should be further noted that a symmetric configuration of the biasing elements 108, 120 does not dictate symmetric positioning of

the viewing elements with respect to the line A-A; in the embodiment shown in FIG. 4 the anterior viewing element 106 is closer to the line A-A than is the posterior viewing element.

Detail Description Paragraph - DETX (12):

[0088] Preferably, both the anterior viewing element 106 and the posterior viewing element 118 comprise an optic or lens having refractive power. (As used herein, the term "refractive" or "refractive power" shall include "diffractive" or "diffractive power".) The preferred power ranges for the optics are discussed in detail below. In alternative embodiments one or both of the anterior and posterior viewing elements 106, 118 may comprise an optic with a surrounding or partially surrounding perimeter frame member or members, with some or all of the biasing elements/translation members attached to the frame member(s). As a further alternative, one of the viewing elements 106, 118 may comprise a perimeter frame with an open/empty central portion or void located on the optical axis (see FIG. 20 and discussion below), or a perimeter frame member or members with a zero-power lens or transparent member therein. In still further variations, one of the viewing elements 106, 118 may comprise only a zero-power lens or transparent member.

Detail Description Paragraph - DETX (19):

[0094] As may be best seen in FIG. 6, the first anterior translation member 110 connects to the anterior viewing element 106 via connection of the left and right arms 110a, 110b to first and second transition members 138, 140 at attachment locations 142, 144. The second anterior translation member 114 connects to the anterior viewing element 106 via connection

of left and right arms 114a, 114b to the first and second transition members 138, 140 at attachment locations 146, 148. This is a presently preferred arrangement for the first and second anterior translation members 110, 114; alternatively, the first and second anterior translation members 110, 114 could be connected directly to the anterior viewing element 106, as is the case with the connection of the first and second posterior translation members 122, 124 to the posterior viewing element 118.

Detail Description Paragraph - DETX (20):

[0095] However the connection is established between the first and second anterior translation members 110, 114 and the anterior viewing element 106, it is preferred that the attachment locations 142, 144 corresponding to the first anterior translation member 110 be farther away from the first apex 112 than is the closest edge or the periphery of the anterior viewing element 106. This configuration increases the effective length of the first anterior translation member 110/arms 110a, 110b, in comparison to a direct or straight attachment between the apex 112 and the nearest/top edge of the anterior viewing element 106. For the same reasons, it is preferred that the attachment locations 146, 148 associated with the second anterior translation member 114 be farther away from the second apex 116 than is the closest/bottom edge of the anterior viewing element 106.

Detail Description Paragraph - DETX (21):

[0096] As best seen in FIG. 7, the first posterior translation member 122 is preferably connected directly to the posterior viewing element 118 via attachment of the left and right arms 122a, 122b to the

element 118 at attachment points 150, 152. Likewise, the second posterior translation member 124 is preferably directly connected to the posterior viewing element 118 via connection of the left and right arms 124a, 124b to the element 118 at attachment points 154, 156, respectively. In alternative embodiments, the first and second posterior translation members 124, 122 can be connected to the posterior viewing element via intervening members as is done with the anterior viewing element 106. No matter how these connections are made, it is preferred that the attachment locations 150, 152 be spaced further away from the first apex 112 than is the nearest edge or the periphery of the posterior viewing element 118. Similarly, it is preferred that the attachment locations 154, 156 be spaced further away from the second apex 116 than is the closest edge of the posterior viewing element 118.

Detail Description Paragraph - DETX (22):

[0097] By increasing the effective length of some or all of the translation members 110, 114, 122, 124 (and that of the arms 110a, 110b, 114a, 114b, 122a, 122b, 124a, 124b where such structure is employed), the preferred configuration of the attachment locations 142, 144, 146, 148, 150, 152, 154, 156 relative to the first and second apices 112, 116 enables the anterior and/or posterior viewing elements 106, 118 to move with respect to one another a greater distance along the optical axis, for a given angular displacement of the anterior and/or posterior translation members. This arrangement thus facilitates a more responsive spring system for the lens system 100 and minimizes material fatigue effects associated with prolonged exposure to repeated flexing.

Detail Description Paragraph - DETX (23):

[0098] In the illustrated embodiment, the attachment location 142 of the first anterior translation member 110 is spaced from the corresponding attachment location 146 of the second anterior translation member 114 along the periphery of the anterior viewing element, and the same relationship exists between the other pairs of attachment locations 144, 148; 150, 154; and 152, 156. This arrangement advantageously broadens the support base for the anterior and posterior viewing elements 106, 118 and prevents them from twisting about an axis parallel to the lateral axis, as the viewing elements move between the accommodated and unaccommodated positions.

Detail Description Paragraph - DETX (24):

[0099] It is also preferred that the attachment locations 142, 144 of the first anterior translation member 110 be located equidistant from the first apex 112, and that the right and left arms 110a, 110b of the member 110 be equal in length. Furthermore, the arrangement of the attachment locations 146, 148, arms 114a, 114b and second apex preferably mirrors that recited above regarding the first anterior translation member 110, while the apices 112, 116 are preferably equidistant from the optical axis and are situated 180 degrees apart. This configuration maintains the anterior viewing element 106 orthogonal to the optical axis as the viewing element 106 moves back and forth and the anterior viewing element flexes.

Detail Description Paragraph - DETX (25):

[0100] For the same reasons, a like combination of equidistance and equal length is preferred for the first and second posterior

translation members 122, 124 and their constituent arms 122a, 122b, 124a, 124b and attachment points 150, 152, 154, 156, with respect to the apices 112, 116. However, as shown the arms 122a, 122b, 124a, 124b need not be equal in length to their counterparts 110a, 110b, 114a, 114b in the first and second anterior translation members 110, 114.

Detail Description Paragraph - DETX (26):

[0101] Where any member or element connects to the periphery of the anterior or posterior viewing elements 106, 118, the member defines a connection geometry or attachment area with a connection width W and a connection thickness T (see FIG. 4 and the example illustrated therein, of the connection of the second posterior translation member 124 to the posterior viewing element 118). For purposes of clarity, the connection width is defined as being measured along a direction substantially parallel to the periphery of the viewing element in question, and the connection thickness is defined as measured along a direction substantially perpendicular to the periphery of the viewing element. (The periphery itself is deemed to be oriented generally perpendicular to the optical axis as shown in FIG. 4.) Preferably, no attachment area employed in the lens system 100 has a ratio of width to thickness less than 3. It has been found that such a geometry reduces distortion of the viewing element/optic due to localized forces. For the same reasons, it is also preferred that each of the translation members 110, 114, 122, 124 be connected to the periphery of the respective viewing elements at least two attachment areas, each having the preferred geometry discussed above.

Detail Description Paragraph - DETX (27):

[0102] FIGS. 17.1 and 17.2 show two preferred cross-sectional configurations which may be used along some or all of the length of the translation members and/or arms 110a, 110b, 114a, 114b, 122a, 122b, 124a, 124b. The shape is defined by a relatively broad and flat or slightly curved outer surface 182. It is intended that when in use the outer surface faces away from the interior of the lens system and/or toward the capsular bag 58. The remaining surfaces, proportions and dimensions making up the cross-sectional shape can vary widely but may advantageously be selected to facilitate manufacture of the lens system 100 via molding or casting techniques while minimizing stresses in the arms during use of the lens system.

Detail Description Paragraph - DETX (28):

[0103] FIG. 17.3 depicts a number of alternative cross-sectional configurations which are suitable for the translation members and/or arms 110a, 110b, 114a, 114b, 122a, 122b, 124a, 124b. As shown, a wide variety of cross-sectional shapes may be used, but preferably any shape includes the relatively broad and flat or slightly curved outer surface 182.

Detail Description Paragraph - DETX (29):

[0104] It is further contemplated that the dimensions, shapes, and/or proportions of the cross-sectional configuration of the translation members and/or arms 110a, 110b, 114a, 114b, 122a, 122b, 124a, 124b may vary along the length of the members/arms. This may be done in order to, for example, add strength to high-stress regions of the arms, fine-tune their spring characteristics, add rigidity or flexibility, etc.

Detail Description Paragraph - DETX (38):

[0112] FIGS. 18 and 19 depict another embodiment 250 of the intraocular lens. It is contemplated that, except as noted below, this embodiment 250 is largely similar to the embodiment disclosed in FIGS. 3-17. The lens 250 features an anterior biasing element 108 and posterior biasing element 120 which are arranged asymmetrically as the lens system 100 is viewed from the side. As used herein to describe the biasing elements 108, 120, "asymmetric" or "asymmetrically" means that, as the lens system 100 is viewed from the side, the first anterior translation member 110 and the first posterior translation member 122 extend from the first apex 112 at unequal first anterior and posterior biasing angles $\delta_{1,1}$, $\delta_{1,2}$ with respect to the line B-B (which represents the edge of a plane which is substantially orthogonal to the optical axis and intersects the first and second apices 112, 116) and/or that the second anterior translation member 114 and the second posterior translation member 124 extend from the second apex 116 at substantially equal second anterior and posterior biasing angles $\delta_{2,3}$, $\delta_{2,4}$ with respect to the line B-B.

Detail Description Paragraph - DETX (39):

[0113] In the embodiment shown in FIGS. 18-19, the first and second anterior biasing angles $\delta_{1,1}$, $\delta_{1,3}$ are greater than the corresponding first and second posterior biasing angles $\delta_{1,2}$, $\delta_{1,4}$. This arrangement advantageously maintains the posterior viewing element 118 and apices 112, 116 in a substantially stationary position. Consequently, the moving mass of the lens system 250 is reduced, and the

anterior viewing element 106 can move more quickly over a wider range along the optical axis under a given motive force. (Note that even where the posterior biasing element 120 and its constituent first and second posterior translation members 122, 124 are substantially immobile, they are nonetheless "biasing elements" and "translation members" as those terms are used herein.) In another embodiment, the anterior biasing element 108 and posterior biasing element 120 are arranged asymmetrically in the opposite direction, i.e. such that the first and second anterior biasing angles $\delta_{1,3}$ are smaller than the corresponding first and second posterior biasing angles $\delta_{2,4}$. This arrangement also provides for a wider range of relative movement of the viewing elements, in comparison to a "symmetric" system.

Detail Description Paragraph - DETX (52):

[0125] FIG. 21.3 shows another alternative configuration of the distending portion 132, in which the distending members 134, 136 are integrally formed with the first and second posterior translation members 122, 124. The distending members 134, 136 and translation members 122, 124 thus form common transition members 139 which connect to the periphery of the posterior viewing element 118.

Detail Description Paragraph - DETX (58):

[0131] The stop members 190 shown in FIG. 22.1 are located on the first and second anterior translation members 110, 114 of the anterior biasing element 108 and extend posteriorly therefrom. When the anterior and posterior viewing elements 106, 118 move together, one or more of the stop members 190 will

contact the posterior translation member(s) 122, 124, thereby preventing further convergent motion of the viewing elements 106, 118.

Of course, in other embodiments the stop member(s) 190 can be in any suitable location on the lens system 100.

Detail Description Paragraph - DETX (62):

[0134] The center mold 506 includes a first center mold cavity 518 which cooperates with the first mold cavity 508 to define a mold space for forming the anterior portion 102 of the lens system 100. The first center mold cavity 518 includes a central anterior mold face 520 which, upon placement of the center mold 506 in the first mold cavity 508, cooperates with the first anterior mold face 510 to define a mold space for the anterior viewing element 106. In so doing, the first anterior mold face 510 defines the anterior face of the anterior viewing element 106 and the central anterior mold face 520 defines the posterior face of the anterior viewing element 106. In fluid communication with the chamber formed by the first anterior mold face 510 and the central anterior mold face 520 are lateral channels 522, 524 (best seen in FIG. 31) which form spaces for molding the first and second transition members 138, 140, along with the arms 110a, 110b of the first anterior translation member 110 as well as the arms 114a, 114b of the second anterior translation member 114. The first center mold cavity 518 also includes retention member cavities 526, 528 which define spaces for molding the first and second retention members 128, 130 to the anterior viewing element 106.

Detail Description Paragraph - DETX (64):

[0136] The center mold 506 includes a second center mold

cavity 552 which cooperates with the second mold cavity 530 to define a mold space for the posterior portion 104 of the lens system 100. The second center mold cavity 552 includes a central posterior mold face 554 which, upon placement of the center mold 506 in engagement with the second mold cavity 530, cooperates with the second posterior mold face 532 and the transition 534 to define a chamber for forming the posterior viewing element 118. In fluid communication with the chamber formed by the central posterior mold face 554 and the second posterior mold face 532 are lateral channels 556, 558, 560, 562 which provide a mold space for forming the arms 122a, 122b of the first posterior translation member 122 and the arms 124a, 124b of the second posterior translation member 124. The second center mold cavity 552 includes lateral projections 564, 566 which coact with the notches 538, 540 formed in the second mold cavity 530. The chambers formed therebetween are in fluid communication with the chamber defined by the central posterior mold face 554 and the second posterior mold face 532 to form the first and second distending members 134, 136 integrally with the posterior viewing element 118.

Detail Description Paragraph - DETX (85):

[0155] FIGS. 37 and 38 show a further embodiment 800 of the lens system, in which the anterior and posterior biasing elements 108, 120 comprise integral "band" like members forming, respectively, the first and second anterior translation members 110, 114 and the first and second posterior translation members 122, 124. The biasing elements 108, 120 also form reduced-width portions 802, 804 which meet at the apices of the lens system 800 and provide regions of high flexibility to facilitate sufficient

accommodative movement.

The depicted distending portion 132 includes three pairs of distending members 134, 136 which have a curved configuration but nonetheless project generally away from the optical axis.

Claims Text - CLTX (3):

2. The lens of claim 1, wherein said elongate members comprise first and second translation members.

Claims Text - CLTX (6):

5. The lens of claim 2, wherein: said first and second translation members together form an anterior biasing element; said lens further comprises a posterior biasing element connected to said anterior biasing element; said posterior biasing element has third and fourth translation members, said third translation member connected to said first translation member at a first apex of said lens, said fourth translation member connected to said second translation member at a second apex of said lens; said lens further comprises a posterior viewing element connected to said third and fourth biasing elements, said first optic and said posterior viewing element being aligned along an optical axis of said lens; and said anterior and posterior biasing elements bias said first optic and said posterior viewing element apart along said optical axis, said first optic and said posterior viewing element being moveable relative to each other to produce a range of accommodation upon implantation of said lens in the eye of a patient.